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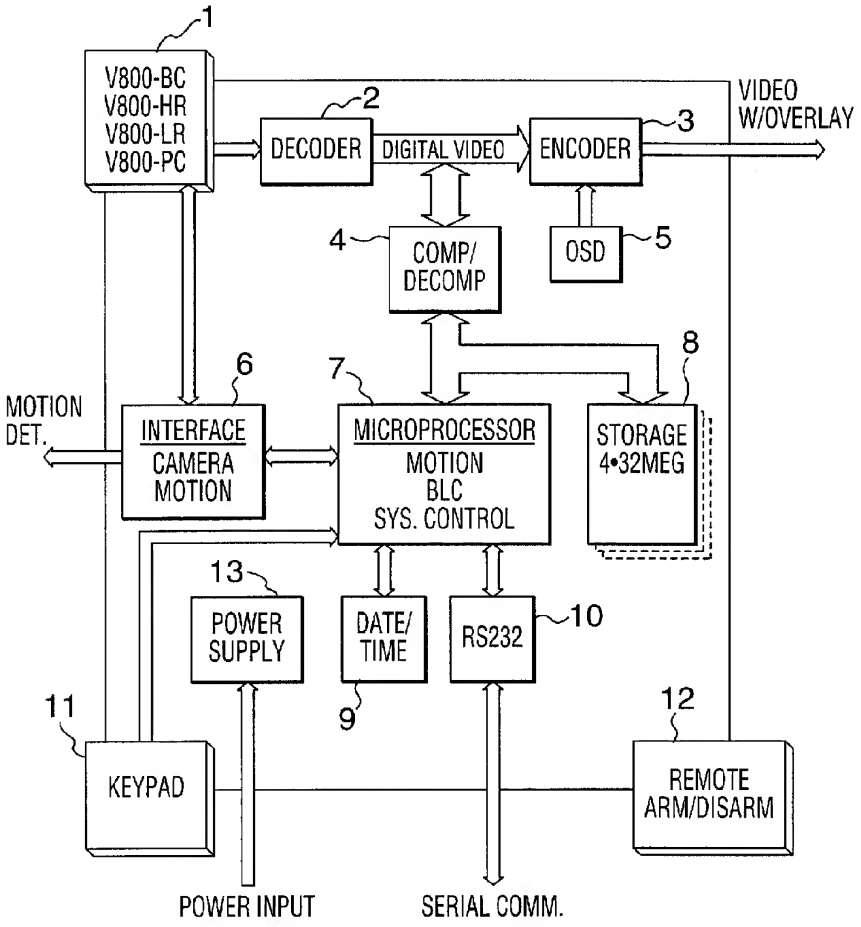
(54) **SYSTEME DE SECURITE VIDEO NUMERIQUE**
(54) **DIGITAL VIDEO SECURITY SYSTEM**



(57) An embedded system for video monitoring and security is disclosed. The embedded system includes a video camera, a user programmable motion detection sub-system which activates the camera and a solid state storage mechanism for collecting the digital video images. All three of the functional units as well as additional hardware and software required for image analysis, compression, storage, playback, and a user interface are all contained within the same vandal resistant enclosure, which is relatively small and easily mountable to almost any surface. Digital video images captured by the camera are processed and continually monitored for unexpected motion. The required memory capacity is reduced by storing the video images in a "time lapse" fashion and storing only when the storage subsystem is triggered by the motion detection subsystem. The solid state storage media provides for increased reliability over older mechanical forms of memory. The user interface takes the form of an on-screen display, where the user can program many system features including: aspects of the motion detection and storage subsystems.

ABSTRACT

An embedded system for video monitoring and security is disclosed. The embedded system includes a video camera, a user programmable motion detection sub-system which activates the camera and a solid state storage mechanism for collecting the digital video images. All three of the functional units as well as additional hardware and software required for image analysis, compression, storage, playback, and a user interface are all contained within the same vandal resistant enclosure, which is relatively small and easily mountable to almost any surface. Digital video images captured by the camera are processed and continually monitored for unexpected motion. The required memory capacity is reduced by storing the video images in a "time lapse" fashion and storing only when the storage subsystem is triggered by the motion detection subsystem. The solid state storage media provides for increased reliability over older mechanical forms of memory. The user interface takes the form of an on-screen display, where the user can program many system features including: aspects of the motion detection and storage subsystems.

DIGITAL VIDEO SECURITY SYSTEM

FIELD OF THE INVENTION

The invention herein disclosed relates to the field of security video monitoring. Specifically the invention is a digital video surveillance system equipped with motion sensing and solid state storage capabilities.

BACKGROUND OF THE INVENTION

Video surveillance systems are part of a continually evolving field, wherein many techniques of image capture and image storage have been employed. Conventional monitoring techniques include a standard analog video camera with analog recording devices such as a VCR. These types of surveillance systems have many associated drawbacks including operation and maintenance costs of VCR equipment and the limited storage capacity of VCR tapes which becomes a significant factor when used in a continuously operating surveillance system. Several recently developed advances have attempted to address these problems.

Innovations in hardware and compression algorithms have made digital video storage a cost effective alternative

to VCR's. The significant advantages of digital video include the ability to process video information before or after storing it and the increased flexibility of storage media offered by digital information. The ability to process digital video has led to the use of video motion detection as a triggering mechanism for the capture of surveillance data, thereby reducing the required storage capacity relative to continuously recording systems.

Various methods of digital video motion detection are discussed in several U.S. Patents including No's 5,754,225 (Naganuma), 5,731,832 (Ng), 5,602,585 (Dickinson et al.), and 5,751,345 (Dozier et al.). The basic algorithm for digital video motion detection involves comparison of a reference video image (i.e. one captured previously) to the incoming video image and looking for changes. A detected motion signal may be used to trigger storage of the video signal. Thus storage space is conserved relative to continuously recording systems.

U.S. Patent No. '225 (issued to Naganuma) discloses a method of digital video motion detection that involves partitioning the video signal into a plurality of areas and calculating an evaluation value for the image within each of the areas. The calculation of an evaluation value can have

several forms including: integrating in a vertical direction peak values of the video signal taken in a horizontal direction, integrating the output of a slice circuit which outputs the video signal when it is in between two predetermined slice levels, and counting the number of pixels in the video signal that are above a certain threshold level. A micro-computer calculates reference evaluation values obtained in an ordinary state and compares the reference evaluation values to the incoming current evaluation values to detect a motion of the image. The problem with the Naganuma process is that its principal purpose is to reduce hardware requirements and as such sacrifices accuracy because of the integration done over each partitioned area as opposed to the entire frame.

U.S. Patent No. '832 (issued to Ng) discloses a method of digital video motion detection that involves generating a difference array by comparing pixel luminescence data for each of a new image and a reference image on a pixel by pixel basis. A difference array is generated and then partitioned into blocks and an average value for each block is put into a difference matrix. Finally, a difference profile of the difference matrix is calculated and compared to a threshold. If the difference profile is greater than

the threshold, then a motion is detected. Despite being more accurate in detection, this technique suffers because it requires a large amount of processing and, therefore, costly implementation hardware.

U.S. Patent No. '585 ,issued to Dickinson et al., discloses a means of analog video motion detection involving a grid of active pixel sensor arrays. Each active pixel sensor array is operative to convert a detected quantity of light into a corresponding voltage which is fed into an output circuit. The output circuits are controlled so as to produce output voltage signals in a serial fashion. The output voltage signals are compared to a threshold level over which a motion is detected. The Dickinson system of motion detection is based on analog as opposed to digital video.

U.S. Patent No. '345 (issued to Dozier et al.) discloses a method of digital video motion detection, but it is based on pixel by pixel comparison of digital still images rather than video. Although essentially the same problem, the Dozier solution is not time limited as a true video solution would be because the rate of capture of the digital stills is substantially less than that of digital video.

Digital video has also led to an increased array of storage mechanisms including magnetic storage devices such as disk drives and tape drives. Disk and tape drive storage techniques are discussed in U.S. Patent No. 5,724,475 (Kirsten) and 5,751,345 (Dozier et al.). Similar to conventional analog video tapes, digital magnetic media such as disk and tape drives are also subject to wear over a period of time. Wear on digital magnetic storage media is particularly a concern when the same disk is written and overwritten a number of times.

The aforementioned patents suffer from a common drawback when used in surveillance systems. They all depend on an external camera to capture the video images and/or external storage mechanisms to record the retrieved data. The systems are not integrated so that the camera, motion detection and storage subsystems are in the same enclosure. Consequently the subsystems are left exposed for potential vandals and criminals who may easily disable the entire surveillance system by damaging any one of its component subsystems. Furthermore, systems which are PC based, rather than embedded, require the additional costs associated with the computer and are susceptible to network crashes, computer transmitted viruses and other PC related problems.

Installation of separated systems can also be a costly problem, when complex cabling is required, particularly for home users, who may not have facilities to run cabling through their residence.

It is an object of the present invention to integrate the three functions of digital image capture (camera), digital video motion detection and digital video storage into an embedded system that is sufficiently small and robust to withstand severe conditions such as an impact, high pressure water spray or other physical trauma.

Another object of the present invention is to provide a cost effective embedded surveillance system with a user interface and on-screen display so that it is operable without any dependence on a PC or other external operational unit, effectively eliminating the need for external cabling and the other costs and problems associated with PC's.

Another object of the present invention is to provide a cost effective solid state storage medium within an embedded surveillance system that can be used to store digital video information without the associated wear that manifests itself in costly mechanical storage media.

Another object of the present invention is to include a motion detection subsystem within an embedded surveillance system so as to reduce the total storage capacity requirement. The motion detection subsystem may be of the digital video type that combines accuracy with minimal hardware requirements and will trigger a storage subsystem to record data and may optionally produce an alarm signal to trigger other devices.

Another object of the present invention is to provide an embedded surveillance system with a total storage capacity requirement that is further reduced by recording video data in a time lapse fashion, where the images are recorded at a reduced rate. The combination of motion detection and reduced frame rate enables effortless retrieval of significant events without poring over hours of useless images.

SUMMARY OF THE INVENTION

An apparatus for an embedded security and surveillance system is disclosed. The apparatus comprises a video camera which captures video images and outputs them in one of several industry standard video formats. The output of the video camera is coupled to a digital video decoder

which converts the video images into digital form at a capture rate of approximately 30 frames per second. A digital solid state storage subsystem is also included in the apparatus. The digital solid state storage subsystem is operative to store, electronically, the video images at a storage rate which is a fraction of the capture rate, the fraction being 1/n where n is an integer greater than or equal to 1. The apparatus also includes a digital video motion detection subsystem which triggers the digital solid state storage subsystem when a motion is detected and also outputs an alarm signal which may be used to trigger other events and devices. A camera interface subsystem is also included in the apparatus. The camera interface subsystem is coupled to both the video camera and the video motion detection subsystem and is operative to adjust the video camera so as to consistently provide a clear video image and to provide pre-processing for the digital video motion detection subsystem. Finally, all of the aforementioned parts and subsystems are housed in a small durable vandal resistant enclosure to form a single embedded structure.

Advantageously, the apparatus may support many various camera types including those which may have the following video formats:

(1) regular resolution EIA (monochrome)
(2) high resolution EIA (monochrome)
(3) regular resolution CCIR (monochrome)
(4) high resolution CCIR (monochrome)
(5) regular resolution NTSC (color)
(6) high resolution NTSC (color)
(7) regular resolution PAL (color)
(8) high resolution PAL (color)

The digital video decoder may convert any of the above mentioned video formats into CCIR601, which is a popular digital video format.

The solid state storage subsystem used by the apparatus may be a FLASH type of memory, which may be exchangeable so as to expand the memory capabilities of the apparatus.

Advantageously, the durable vandal resistant enclosure may be made of poly-carbonate material which is highly resistant to impact and other extreme conditions.

Preferably, the digital video motion detection subsystem may be operative to analyze certain user defined sectors within the video images for motion and, based on a user defined sensitivity threshold, make a decision whether to trigger the digital solid state storage subsystem.

The apparatus may also comprise a user interface which provides user input and output from the embedded security and surveillance system. User input may be received from a keypad on the apparatus. User output may include a video output signal with an overlaid on-screen display which may provide the user with information such as: time, date, and menuing functions for the user interface. The user interface may allow the user to monitor and alter several features including:

(a) the storage rate, which determines a rate at which video images are stored when the digital video storage subsystem is triggered;

(b) the user defined sectors within the video images, which determine which sectors will be analyzed for motion by the digital video motion detection subsystem;

(c) a sensitivity threshold for the digital video motion detection subsystem, which determines what level of motion will trigger the digital video storage subsystem; and

(d) a digital video frame file size which determines the resolution at which the digital video storage subsystem records the video images.

The system may also include a programmer interface such as a serial port which is operative to input and output program and diagnostic information. Advantageously, the apparatus may include a remote arm/disarm capability that will allow the user to activate/deactivate the device without having to contact it.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. **1-a** and Fig. **1-b** depict a preferred embodiment of the invention. The video camera aperture and the vandal resistant enclosure are shown.

Fig. **2** depicts schematically the electronic architecture of the apparatus displaying all of the subsystems.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. **1-a** and Fig. **1-b** depict the entire security and surveillance apparatus with the vandal resistant enclosure **4**.

The camera aperture **1** and the microphone **3** are shown in the front of the enclosure **4.** The enclosure **4** is held together with security bolts **6**. Optional cables **5** lead directly into a wall or ceiling (without exposure) and carry video information to a monitor (not shown) for immediate monitoring if desired by the user. Typically, however, the unit will not include the cables **5** making it a truly stand alone system, which can be detached and moved to a location with a monitor for playback. The keypad **10** provides a user input device which can be used to select the user-programmable features with the aid of the on-screen display.

Fig. **2** shows a schematic diagram of the electronic architecture of a preferred embodiment of the invention. The video camera **1** captures video images in one of eight different types of video formats which include regular and high resolution EIA, CCIR, NTSC, and PAL analog video standards.

The video decoder **2** converts the industry standard EIA/CCIR/NTSC/PAL video into a standard digital format called CCIR601. The circuit that performs this function is a standard "off-the-shelf" integrated circuit.

The solid state storage subsystem includes, the compression/decompression block **4**, the microprocessor **7**, and the storage chips **8**. The compression/decompression block **4** takes the digital video (from the decoder **2**) and compresses it for storage in memory **8** and also takes the stored images and decompresses them for playback via the user interface. The compression algorithm employed is wavelet compression, as opposed to the more standard schemes such as JPEG, MPEG, etc. The microprocessor **7** is the central controlling unit for the entire embedded system and one of its functions includes controlling the memory access. The memory **8** is a non-volatile memory used to store the compressed images. The amount of memory **8** included in the solid state storage subsystem determines the maximum number of video frames that can be stored. The memory chips **8** may be exchangeable so as to allow "plug-in" cartridges of memory that expand the total storage capacity of the device.

The digital video motion detection subsystem includes: the microprocessor **7** and the camera/motion interface **6**. The camera/motion interface **6** pre-processes the information from the camera **1** to help detect motion in the video scene. The microprocessor **7** analyzes the motion and determines the significance of the motion in the video scene

to control image recording. Motion detection is the key to recording images, such that when a motion of significance is detected, the microprocessor will interface with the solid state storage subsystem to store the compressed images in memory for retrieval later.

The camera interface subsystem consists of the camera/motion interface **6** and the microprocessor **7**. The microprocessor **7** is continually analyzing the incoming video images to determine lighting and other criteria to ensure that the video images that are captured are clear. The camera/motion interface chip **6** provides the interface from the microprocessor **7** to the camera **1**.

The user interface for the apparatus includes: the keypad **11**, the on-screen display **5**, and the encoder **3**. The encoder **3** converts the digital video back to analog for viewing on a monitor (not shown). The on-screen display **5** is added into the video signal to provide overlaid information such as the time, date and menuing options. The 4 button keypad **11** is provided to allow a user to manipulate the on-screen display **5** as well as to control the playback of stored images. Other switches separate from the keypad **11** are also included to allow for some simple setup features.

A programmer interface **10** is also included to permit software upgrades and other programmer related services.

In normal operational mode, the video camera **1** is capturing video images which are decoded by the digital video decoder **2** at a rate of 30 frames per second and compressed by compressor **4** for processing and/or storage. The captured frames are used by the camera interface subsystem to adjust features such as camera aperture and other camera adjustments in accordance with the present light conditions. The digital video motion detection subsystem is continually comparing the captured images for motion in the user defined sectors of the frame. The digital video motion detection subsystem runs the digital data through a low pass filter to reduce the information content contained in the image. Each value in the newly filtered digital image corresponds to information from many original samples in the original composite video input. The newly filtered digital image is then filtered again in a Sobel filter implementation so as to extract edge information. Thus the image is removed and only an edge profile remains in the data. This second filtering operation reduces the chances that false triggering may occur because of amplitude differences from scene to scene being interpreted as movement within the scene. The current

filtered digital "image" is then compared to the last filtered digital "image". If the number of pixels that exceed a first threshold is higher than a second user defined threshold level of "significance", then the digital solid state storage subsystem is triggered and the compressed video images are stored in memory **8** until required for playback. When a next digital image arrives, the current image is assigned to being the old image and the process begins anew. The digital video images are stored at a user defined storage rate that is a fraction of the capture rate. The preferred embodiment allows storage between 0.2 and 5 frames per second. This preserves the motion video "feel", but reduces the corresponding memory requirements. A user can also select the file size that they want to store. The file size of each image is variable, so that the user can trade off image resolution to total capacity for the number of images stored. Stored images can be retrieved from memory **8** for playback on a monitor (not shown). The on-screen display **5** is overlaid onto the decoded video output so that the user is provided information such as date and time of the recorded images that they are viewing.

WHAT IS CLAIMED IS:

1. An embedded security and surveillance apparatus for a remote location, which apparatus comprises:

(a) a video camera operative to capture video images and output them in a standard video format;

(b) a digital video decoder coupled to said video camera, said digital video decoder operative to convert said video images into digital form at a capture rate corresponding to a standard format for digital video;

(c) a digital solid state storage subsystem coupled to said digital video decoder, said digital solid state storage subsystem operative to store, electronically, said video images at a storage rate which is a fraction of said capture rate, said fraction being 1/n where n is an integer greater than or equal to 1;

(d) a digital video motion detection subsystem coupled to both said digital video decoder and said digital solid state storage subsystem, said digital video motion detection subsystem being operative to trigger

said digital solid state storage subsystem when a motion is detected and to output an alarm signal which may be used to trigger other events and devices;

(e) a camera interface subsystem coupled to both said video camera and said digital video motion detection subsystem, said camera interface system operative to observe said video images and adjust said video camera so as to consistently provide a clear video image and to provide pre-processing for said digital video motion detection subsystem;

(f) a durable vandal resistant enclosure which houses said video camera, said digital video decoder, said solid state storage subsystem, said motion detection subsystem and said camera interface subsystem in a single embedded structure.

2. An apparatus according to claim 1, wherein said video camera outputs a video format which is one of: regular or high resolution Electronic Industries Association (EIA) and Center for Communication Interface Research (CCIR) in a monochrome system and regular or high

resolution National Television System Committee (NTSC) and Phase Alternating Line (PAL) in a color system.

3. An apparatus according to claim 2, wherein said digital video decoder is operative to convert said EIA, CCIR, NTSC, and PAL video format into Center for Communication Interface Research 601 (CCIR601) digital video format.

4. An apparatus according to claim 1, wherein said solid state storage subsystem is one of a FLASH type and other non-volatile RAM types of memory.

5. An apparatus according to claim 1, wherein said solid state storage subsystem is replaced by one of a writable magnetic, magneto-optic, and optic storage unit.

6. An apparatus according to claim 1, wherein said solid state storage system is expandable by using exchangeable storage media.

7. An apparatus according to claim 1, wherein said durable vandal resistant enclosure is constructed from poly-carbonate material.

8. An apparatus according to claim 1, wherein said digital video motion detection subsystem is operative to analyze certain user defined sectors within said video images for motion and, based on a user defined significance threshold for an amount of motion, make a decision whether to trigger said digital solid state storage subsystem.

9. An apparatus according to claim 1, which further comprises a user interface which is operable to provide user input and output from said embedded security and surveillance apparatus.

10. An apparatus according to claim 9, wherein said user interface includes a miniature keypad operative to provide user input and a video output signal with an overlaid on-screen display operative to provide user output.

11. An apparatus according to claim 10, wherein said on screen display provides a user with information that indicates time, date, and menuing functions for said user interface.

12. An apparatus according to claim 9, wherein said user interface is operative to allow a user to select said storage rate, which determines a rate at which video images are stored when said digital video storage subsystem is triggered.

13. An apparatus according to claim 9, wherein said user interface is operative to allow a user to select said user defined sectors within said video images, which determine which sectors will be analyzed for motion by said digital video motion detection subsystem.

14. An apparatus according to claim 9, wherein said user interface is operative to allow a user to select said sensitivity threshold for said digital video motion detection subsystem, which determines what level of motion will trigger said digital video storage subsystem.

15. An apparatus according to claim 9, wherein said user interface is operative to allow a user to select a digital video frame file size which determines the resolution at which said digital video storage subsystem records said video images.

16. An apparatus according to claim 1, which further comprises a programmer interface.

17. An apparatus according to claim 16, wherein said programmer interface is a serial port.

18. An apparatus according to claim 1, which further comprises a remote arm and disarm device which remote arm and disarm device is operative to turn said apparatus on and off.

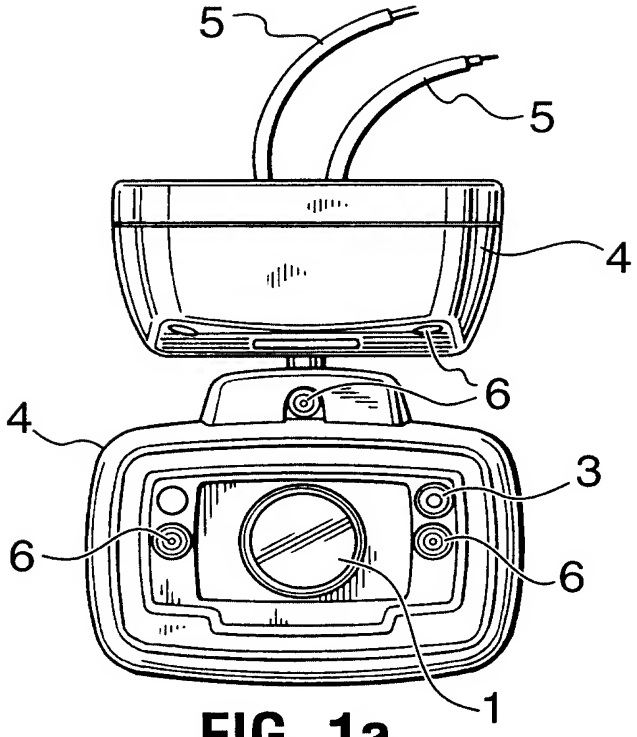


FIG. 1a

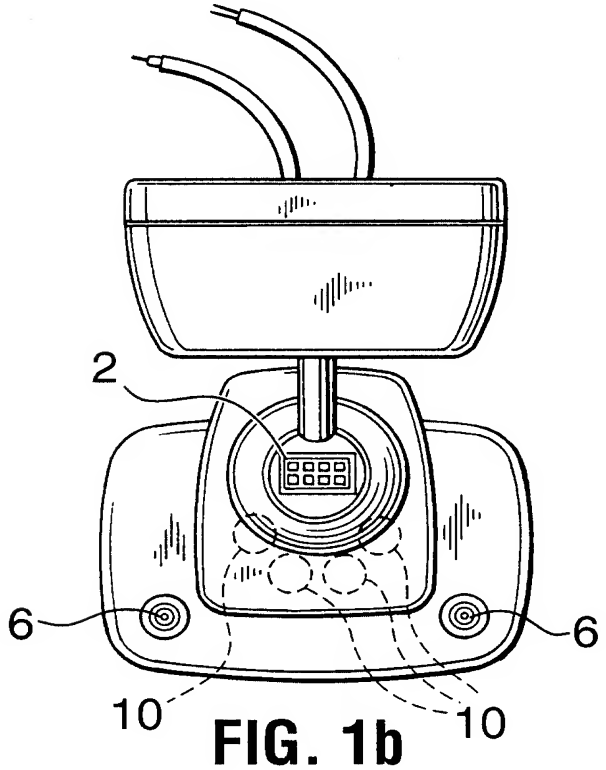


FIG. 1b

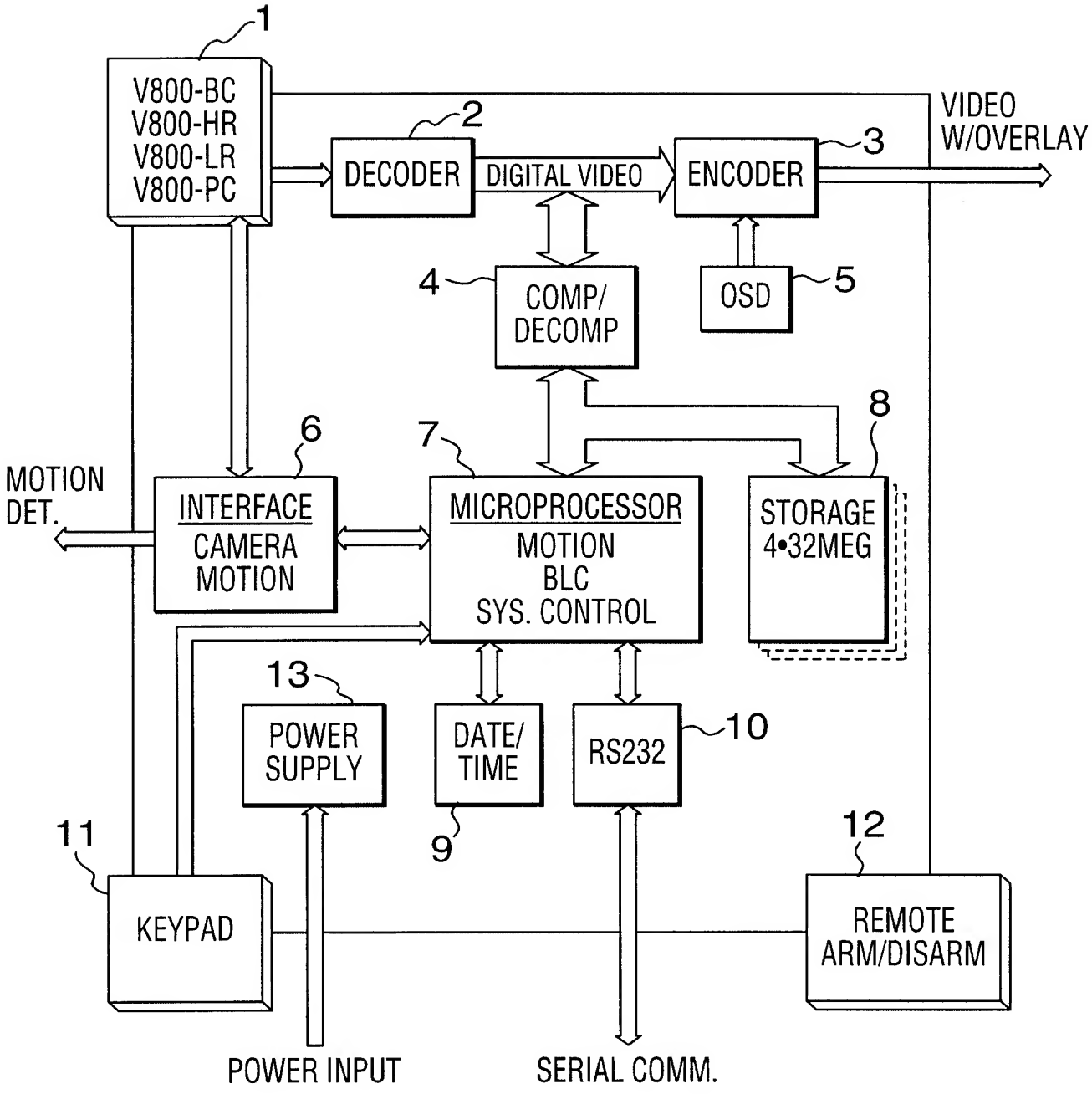

1
V800-BC
V800-HR
V800-LR
V800-PC
2
DECODER
DIGITAL VIDEO
ENCODER
3
VIDEO
W/OVERLAY
4
COMP/
DECOMP
OSD
5
6
7
8
MOTION
DET.
INTERFACE
CAMERA
MOTION
MICROPROCESSOR
MOTION
BLC
SYS. CONTROL
STORAGE
4•32MEG
13
POWER
SUPPLY
DATE/
TIME
RS232
10
9
11
12
KEYPAD
REMOTE
ARM/DISARM
POWER INPUT
SERIAL COMM.

FIG. 2